

NON-DESTRUCTIVE TRACE ELEMENT MICROANALYSIS OF AS-RECEIVED COMETARY NUCLEUS SAMPLES USING SYNCHROTRON X-RAY FLUORESCENCE; S. R. Sutton, Department of the Geophysical Sciences, The University of Chicago, Chicago, IL 60637 and Department of Applied Science, Brookhaven National Laboratory, Upton, NY 11973.

The Synchrotron X-ray Fluorescence (SXRF) Microprobe at the National Synchrotron Light Source (NSLS), Brookhaven National Laboratory, will be an excellent instrument for non-destructive trace element analyses of cometary nucleus samples [1,2]. Analyses of individual, cometary mineral grains are discussed in an accompanying abstract by Flynn and Sutton and will complement currently active research on micrometeorites collected from the stratosphere [3]. Trace element analyses of *as-received* cometary nucleus material will also be possible with this technique. Bulk analyses of relatively volatile elements will be important in establishing comet formation conditions. However, as demonstrated for meteorites, microanalyses of individual phases in their petrographic context are crucial in defining the histories of particular components in unequilibrated specimens. Perhaps most informative in comparing cometary material with meteorites will be the halogens and trace metals. In-situ, high spatial resolution microanalyses will be essential in establishing host phases for these elements and identifying terrestrial (collection/processing) overprints.

The present SXRF microprobe is a simple, yet powerful, instrument in which specimens are excited with filtered, continuum synchrotron radiation from a bending magnet on a 2.5 GeV electron storage ring [4,5]. X-ray beams down to 20 micrometers are produced with a continuously adjustable collimator. X-ray spectra are obtained in air with an energy dispersive Si(Li) detector. Detection limits are near 1 ppm for virtually all elements above silicon using either K or L transitions. The microprobe has been extensively applied to problems in the earth, biological and materials sciences [6,7].

Intense, high energy x-ray excitation results in minimal energy deposition, unlike charged particle techniques employed by electron, proton, and ion microprobes. The NSLS x-ray bending magnets emit about 2×10^{11} photons/sec between 3 and 30 keV into a 100 μm spot (200 mA at 20 m from the source after 100 μm Al filtering). A 100 μm thick, ice/silicate aggregate will absorb only a few percent of these photons resulting in a total deposition rate of about 10^{-5} cal/sec. The corresponding power density is 10^{-10} W/ μm^3 compared to 10^{-4} W/ μm^3 for an electron microprobe (10 kV and 10 nA). Such a sample will have an effective thermal conductivity of about 10^{-3} cal sec $^{-1}$ cm $^{-1}$ K $^{-1}$ and can lose energy conductively at a rate ten times greater than this deposition rate. Experiments on live isolated biological cells have demonstrated the non-destructive nature of this technique [7].

A refrigerated cell will be constructed to permit analyses at low temperatures. The cell will consist essentially of an air tight housing with a cold stage. Kapton windows will be used to allow the incident synchrotron beam to enter the cell and fluorescent x-rays to exit it. The cell will be either under vacuum or continuous purge by ultrapure helium during analyses.

Several improvements of the NSLS microprobe will be made prior to the cometary nucleus sample return mission that will greatly enhance the sensitivity of the technique. First, a focusing mirror will increase the photon flux at the specimen about 1000-fold. Second, a monochromator will allow selective elemental excitation. Third, a wavelength dispersive detector will improve energy resolution. In addition, advanced synchrotron sources will come on-line. A superconducting wiggler insertion device will be commissioned at NSLS during 1989 offering more intensity and higher energy x-rays than the bending magnets. The availability of high flux at x-ray energies above 50 keV will allow efficient K excitation of high atomic number elements such as REE and platinum group elements. A major advance will occur in 1995 with the commissioning of the Advance Photon Source at Argonne National Laboratory [8]. The low emittance, high energy undulators on this

positron storage ring will be ideal for an x-ray microprobe in the 5-40 keV range with micrometer resolution and better than 100 ppb sensitivity [9].

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